THEORETICAL AND EXPERIMENTAL INVESTIGATION OF A THREE-DIMENSIONAL MAGNETIC-SUSPENSION BALANCE FOR DYNAMIC STABILITY RESEARCH IN WIND TUNNELS

TECHNICAL SEMI-ANNUAL STATUS REPORT

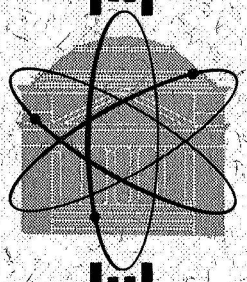
1 MARCH 1968 - 1 DECEMBER 1968

National Aeronautics and Space Administration

Grant No. NGR-47-005-029

Submitted by:

H. M. Parker, R. N. Zapata, G. B. Matthews
Principal Investigators



Research Laboratories for the Engineering Sciences

University of Virginia

Charlottesville

Report No. AST-4030-106-68U

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FOREWORD

The Cold Balance Project has been a team effort ever since it took definite shape. Its final success will depend on many individuals being capable of pushing the frontiers of technology in their fields of specialty a little further and being able to coordinate their efforts with the other members of the team. This is what makes it such an exciting challenge to all those participating in it. But also, this makes it so much harder to have to accept the loss of a member of the team. On September 22, 1968, Robert Russell, who was handling the power supplies aspect of the project with great competence and enthusiasm, was killed in an automobile accident. It is agreat personal loss for those of us who were counted among his friends. It is a great loss for the Cold Balance project. But we must move on. On December 15, 1968, Mr. Carl Henderson will begin working in the Electrical Engineering Department of the University of Virginia and will assume Mr. Russell's duties in our project, under the supervision of Professor Eugene McVey. Mr. Henderson's background should be a guarantee that, after an initial period of orientation, he will be able to bring the power supplies and control circuit back into schedule with the rest of the components of the balance.

INTRODUCTION

The current Cold Magnetic Wind Tunnel Balance project at the University of Virginia has the following stated objectives:

1) Construction of a prototype electromagnetic balance-wind tunnel facility to evaluate the feasibility of the 3-D magnetic suspension for dynamic stability studies;

2) Analysis and testing of the design parameters that are critical for extrapolation to a large scale test facility.

In a comprehensive Technical Annual Status Report [1] submitted in March 1968, details of the design of the prototype facility were given and plans, both short-range and long-range, were discussed. In a subsequent communication, in support of a request for additional funds and for a time extension [2], a time-table covering the period September 15, 1968 to September 15, 1969 was proposed. The purpose of the present report is to outline the progress effected since March 1968 vis-a-vis that proposed time-table.

PROGRESS SINCE MARCH 1968

A. Superconducting Coils

Coil forms have been fabricated by CRYENCO and sent to Atomics International. Coils will be ready for acceptance tests in January or February 1969.

B. Helium Dewar

Main feature of the design is the fabrication of all inner walls (between the coils and the wind tunnel) of fiberglass to avoid eddy current problems. The dewar is being fabricated by CRYENCO and will be sent to Atomics International in late December 1968 for the coil acceptance tests.

C. Current Leads

All the leads were fabricated at the University of Virginia during the summer, following a design originated by Efferson [3].

D. Cryogenic Subsystems

A low temperature sensing system was designed and built. All components of the helium vapor circuit are ready for assembly. The helium return line between the cold balance facility site and the helium liquefying plant in the Physics Building is finished.

E. Facility Site

The pit and supporting pillars where the cold balance will be mounted were completed last summer. Electric power and water for auxiliary equipment were installed.

F. Wind Tunnel

A Mach 3 nozzle was designed and fabricated out of fiberglass (Brunswick Corporation). The general design of the wind tunnel was completed [4] and preliminary tests carried out. Special emphasis was put on increasing the pressure recovery of the tunnel in order to use the (limited) available air supply with maximum efficiency. Current efforts are concerned with reducing the overall length of the wind tunnel and with the interface mechanisms for transfer from mechanical to magnetic support of the models.

G. Position Sensor

A full scale prototype of an electromagnetic position sensor was built and tested [5]. At present the circuitry is being refined in order to improve the signal to noise ratio. In addition, the optimum geometry of the shorted turn to be mounted in the aerodynamic models is being investigated. Finally, a concept utilizing an additional set of sensing coils for roll detection is being developed.

H. Control Circuit

A series of realistic simulation experiments to study the behaviour of the proposed control circuit was carried out in the analog computer. Results indicate that, within the limits of expected balance operation, the performance of the control loop will be highly satisfactory. The actual building of the circuit will start shortly, as soon as Mr. Henderson becomes thoroughly familiar with the details of the project.

I. Data Acquisition Studies

Work has continued on the study of methods to get aerodynamic information out of the cold balance tests. A careful survey of the methods used in

other laboratories has been completed, including personal contacts with the groups at Notre Dame, BRL and MIT. From the experimental point of view, current efforts are being directed at developing an adequate optical system for visual observation of the suspended models. Finally, work on the angular detection capability of the electromagnetic position sensor will begin as soon as the circuit refinements are completed.

J. Error Analysis

The important question of the quality of the expected measurements from the point of view of the aerodynamic coefficients being sought is being carefully evaluated. A reliable answer to this question is essential for detail specification and design of a data acquisition system.

K. Rigid Body Dynamics Studies

The comparative analysis of the description of a rigid body motion using laboratory coordinate system and body coordinate system is nea completed.

L. Power Supplies for Gradient Coils

Technical contact with the Brown Boveri Company (Switzerland), which accepted the order to fabricate the power supplies, has been maintained throughout the report period. Brown Boveri has built a full scale prototype and last reports from them indicate that they still expect to meet the specified mid-summer 1969 delivery. Mr. Henderson will very shortly establish personal contact with the American representatives of Brown Boveri and will go to Switzerland when the first unit is assembled as agreed in the contract.

The time table proposed in reference [2] still looks about right, barring unexpected delays or difficulties. It can be anticipated that a more reliable estimate on completion date will be available at the time of the next report.

REFERENCES

[1] Technical Annual Status Report, 1 March 1967 - 1 March 1968, Report No. AST-4030-105-68U, March 1968.

[2] Letter of request to Mr. Smith (March 25, 1968).

[3] K. R. Epperson, Rev. Sci. Instr., vol. 38, no. 12, pp. 1776-79, December 1967.

[4] T. Radovich, Master's Thesis (final draft due January 1969).

[5] T. Liebfried, Master's Thesis, August 1968 (to be published as RLES report).

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